PARTICULATE MATTER CONCENTRATION-RESPONSE VERSUS DOSE-RESPONSE

Author(s): **J. S. Brown and L. D. White**

Affiliation(s): **U.S. Environmental Protection Agency, National Center for Environmental Assessment, RTP, NC**

INTRODUCTION

Epidemiological studies have reported associations between short-term increases in ambient particle concentrations and increases in respiratory and cardiovascular morbidity and mortality.

Since 1995, a number of animal and human studies have been performed using concentrated ambient air particles (CAPs) to elucidate the mechanisms of PM effects. Ideally, CAPs studies have full control over all exposure variables, making it possible to establish a firm linkage between exposure, dose, and biological effects.

The focus of this this presentation is the size distribution of CAPs and its influence on estimates of dose in the respiratory tract.

METHODS

Particle deposition in the extrathoracic (ET), tracheobronchial (TB), and pulmonary (PU) regions of the lungs was calculated using a publicly available model (Multiple Path Particle Dosimetry, MPPD). The deposition fraction (DF_r) in a region of the respiratory tract depends mainly on inhaled particle size, lung morphology, and breathing conditions.

Once a DF_r has been estimated, the dose rate of particles in a region of the respiratory tract is given by:

$$\dot{D}_r(t) = C(t) \times f(t) \times V_T(t) \times DF_r(t)$$

where: C is particle concentration, *f* is breathing frequency, and V_T is tidal volume. For multiple day exposures, regional burden (B_r) can subsequently be estimated:

$$dB_r(t)/dt = \dot{D}_r(t) - \lambda_r B_r(t)$$

where: λ_r is a clearance rate constant for a region.

While reviewing the CAPs literature and attempting to estimate regional lung doses, several problems became apparent with regard to exposure data, viz., it was inadequately characterized for accurate dose estimates. For example, some studies report only exposure concentration or ambient particle size distribution which is insufficient to estimate dose.

Even when the particle size distribution is reported, the underlying assumption of log-normality can also be problematic. We have evaluated the effect of assuming a log-normal CAPs size distribution on dose estimates. Simulations were conducted for an ambient aerosol having variable fractions in the accumulation and coarse modes. The below tables contain simulation input parameters.

Ambient Aerosol Assumptions

	Accumulation	Coarse
Median Diameter, µm	0.31	5.7
Geometric Std. Dev.	2.03	2.15
Mass, %total	0-100	0-100

Breathing Condition Assumptions

	Human		Rat
Activity	Slow walk	Heavy exertion	Awake rest
Tidal volume, mL	813	1923	2.1
Breaths/min	16	26	102
Time, %exposure	50	50	100

RESULTS

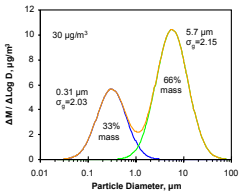

Figure 1A. Ambient aerosol composed of accumulation and coarse modes.

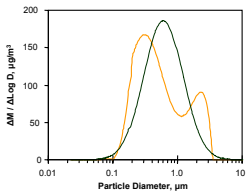

Figure 1B. Concentrated ambient aerosol. Ambient aerosol illustrated in Fig. 1A. Assumed 30-time enrichment of particles between approximately 0.1 and 2.5 µm. The black line illustrates a fitted log-normal particle size distribution (Fig. 2B).

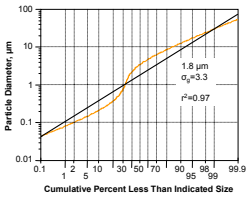

Figure 2A. Log-probability plot of ambient aerosol (Fig. 1A) and a log-normal fit.

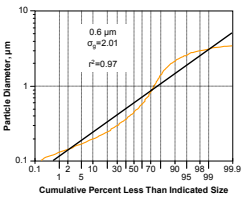

Figure 2B. Log-probability plot of concentrated ambient aerosol (Fig. 1B) and a log-normal fit.

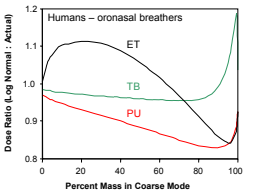

Figure 3A. Ratio of dose in humans estimated by assuming a log-normal distribution relative to the actual particle size distribution.

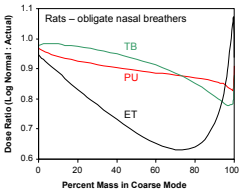

Figure 3B. Ratio of dose in rats estimated by assuming a log-normal distribution relative to the actual particle size distribution.

CONCLUSIONS

Intrathoracic respiratory doses were generally underestimated when a log-normal CAPs distribution was assumed.

The influence of assuming log-normality on dose estimates varied as a function of the ambient aerosol distribution and the exposed species.

Uncertainty in dose estimates affects the ability to compare studies.

Assumptions regarding log-normality of aerosol distributions should be carefully considered.

DISCLAIMER

The views expressed in this poster are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

ACKNOWLEDGMENTS

The MPPD model, used here to estimated particle deposition in the lungs of humans and rats, was developed by the CIIT Centers for Health Research (CIIT), USA, in collaboration with the National Institute of Public Health and the Environment (RIVM), the Netherlands, and the Ministry of Housing, Spatial Planning and the Environment, the Netherlands.